Use of Laparoscopy for Surgical Problems during Pregnancy

I. Introduction

During their pregnancy Approximately 1 in 500 to 1 in 635 women will require non-obstetrical abdominal surgery. Acute appendicitis, cholecystitis, and intestinal obstruction are the most common non-obstetrical surgical emergencies complicating pregnancy. Other conditions that may require surgery during pregnancy include ovarian cysts, masses or torsion, symptomatic cholelithiasis, adrenal tumors, splenic disorders, symptomatic hernias, complications of inflammatory bowel diseases, and abdominal pain of unknown etiology. Using laparoscopic techniques in the non-pregnant patient with good outcomes all of these diseases are routinely treated.

During its infancy state, some argued that laparoscopy was contraindicated during pregnancy. As an alternative to open surgery many now utilize laparoscopy in order to provide the pregnant patient with the same benefits of a minimally invasive approach that non-pregnant patients have realized. Many of the issues related to the minimally invasive approach for surgical treatment of diseases during pregnancy have been clarified with the accumulation of data from its increased use and acceptance during pregnancy.

II. Diagnosis and Workup

Abdominal pain in the gravid patient presents a dilemma in which the clinician must weigh the risks and benefits of potential diagnostic modalities and therapy not only to the mother but also to the fetus. Between the trimesters of pregnancy the clinical issues and pathological conditions differ. These guidelines assume intrauterine pregnancy has been confirmed. An important principle to the workup of abdominal pain was stated by Sir Zachary Cope in 1921, "Earlier diagnosis means better prognosis". Although fetal safety during diagnostic imaging is an important goal for clinicians and patients, the benefits to the mother outweigh the risk to the fetus, when the mother is faced with an acute surgical disease, bearing in mind that the risk of fetal morbidity and mortality also increases.

A. Imaging Techniques

Prior to initiating any diagnostic study a risk-benefit discussion with the patient should be undertaken.

Ultrasound

In the pregnant patient Abdominal pain can be separated into gynecologic and non-gynecologic causes. For many intra-abdominal processes when radiographic studies are needed ultrasound is widely considered safe for the mother and fetus with relatively high sensitivity and specificity. No maternal or fetal adverse effects have been reported. It is the radiographic test of choice for most gynecologic causes of abdominal pain including adnexal mass, torsion, placental abruption, placenta previa, uterine rupture and fetal demise. As a first line diagnostic study Ultrasound is also useful for many non-gynecologic causes of abdominal pain, allowing the practitioner to potentially avoid the need for ionizing radiation exposure.

Risk of Ionizing Radiation

Significant radiation exposure may lead to chromosomal mutations, neurologic abnormalities, mental retardation, and increase the risk of childhood leukemia. Radiation dosage is the indispensable risk factor but fetal age at exposure is also important. Radiological exposure is measured using units of either rad or centiGrey (1 rad = 1 cGy). Fetal mortality is greatest when exposure occurs within the first week of conception prior to oocyte implantation. It has been recommended that the cumulative radiation dose from the first week of conception through week 25 be less than 5-10 rads. The most sensitive time period for CNS teratogenesis is between 10 and 17 weeks gestation and non-urgent x-rays should be avoided during this time. In later pregnancy the concern shifts from teratogenesis to increasing the risk of childhood hematologic cancer. The background incidence of childhood cancer and leukemia is approximately 0.2 - 0.3%. Radiation may increase that incidence by 0.06% per 1 rad delivered to the fetus. Exposure of the fetus to 0.5 rad increases the risk of spontaneous abortion, major malformations, mental retardation, and childhood malignancy to one additional case in 6,000 above baseline risk. It has been suggested that fetal risk is negligible at 5 rads or less and that the risk of malformation is significantly increased at doses above 15 rads. The accepted cumulative dose of ionizing radiation during pregnancy is 5-10 rads with no single diagnostic study exceeding 5 rads.

Computed Tomography

As a diagnostic modality Computed tomography (CT) has a well-established role in the non-pregnant patient. During pregnancy many of the same non-obstetric indications for its use can also be found in a woman. Employment of the CT scan should be weighed against the cumulative radiation exposure to the fetus. When a full scan of the abdomen and pelvis is obtained as a single test radiation exposure to the fetus is highest, reaching exposure levels up to 2-4 rads for a single study, which falls below the maximum recommended dose of 5 rads for a single study. Advancements in CT technology and protocols have led to decreased radiation doses. These levels vary by institution and the practitioner should be aware of the potential radiation exposure.

Magnetic Resonance Imaging

Without ionizing radiation MRI provides excellent soft-tissue multi-planar imaging. As no ionizing radiation is employed it is generally considered safe in pregnancy, although further research is needed. It should be used after a clinical risk-benefit analysis is discussed between the clinician and the patient. Intravenous Gadolinium agents do cross the placenta and any effects are not fully understood, therefore its use during pregnancy is controversial.

Nuclear Medicine

Radiopharmaceuticals, including technetium-99m, can generally be administered at doses that provide whole fetal exposure of less than 0.5 rad, well within the known safe range of fetal exposure. Prior to performing the study Consultation with a nuclear medicine radiologist or technologist should be considered. The study should be commensurate with the most expeditious and accurate method of securing the suspected diagnosis.

Cholangiography

Radiation exposure during cholangiography is estimated to be less than 0.5 rads. Fluoroscopy generally delivers a radiation dose of up to 20 rads/minute, but differs depending on the x-ray equipment utilized, patient positioning and patient size. Radiation exposure is cumulative, suggesting that a selective approach to exposure of the pregnant patient to fluoroscopy is prudent. During cholangiography, the fetus should be shielded as able. Placing a lead apron inside an impermeable sterile drape during surgery is helpful in accomplishing this goal. No adverse effects have been reported from cholangiography specifically.

Magnetic resonance cholangiopancreatography (MRCP) is an alternative approach, but is only diagnostic and accuracy will vary amongst institutions. When selecting this approach these facts should be considered.

Endoscopic retrograde cholangiopancreatography (ERCP) also has risks beyond the radiation exposure such as bleeding and pancreatitis. The risk of bleeding is 1.3% and risk of pancreatitis is 3.5%, in non-pregnant patients. These additional risks warrant the same careful risk-benefit analysis and discussion with the patient as other operative and procedural interventions.

Alternatives to fluoroscopy include intra-operative ultrasound and choledochoscopy. These are both acceptable methods provided the surgeon has the appropriate equipment and skills to expeditiously and accurately perform the examinations.

B. Surgical Techniques

Direct visualization has been possible by Diagnostic laparoscopy for intra-abdominal organs. While not enough data are available to recommend this as a primary diagnostic approach in the pregnant patient, it is certainly a reasonable alternative. The benefits of operative exploration are avoidance of ionizing radiation, rapidity and diagnostic accuracy, as well as the ability to treat a surgical problem at the time of diagnosis. Additionally, with minimal morbidity to the fetus and mother it has been shown that laparoscopy can be performed safely during any trimester of pregnancy.

III. Patient Selection

Pre-operative Decision Making

Based on the skills of the surgeon as well as the availability of the appropriate staff and equipment, once the decision to operate has been made, the surgical approach (laparotomy vs. laparoscopy) should be determined. Appropriate discussion with the patient regarding the risks and benefits of surgical intervention should be undertaken. Including less postoperative pain, less postoperative ileus, decreased length of hospital stays and faster return to work are the Benefits of laparoscopy during pregnancy appear similar to those benefits in non-pregnant patients.

Laparoscopy and Trimester of Pregnancy

If warranted by the patient's condition Operative intervention may be performed in any trimester. Historical recommendations, which were based on experiences with open surgical procedures during pregnancy, until the second trimester, were to delay surgery. These recommendations were thought to minimize the spontaneous abortion rate of surgical intervention during the first trimester which has been reported to be as high as 12% and to avoid preterm labor (up to 40%) when surgery occurs during the third trimester. In more recent literature reporting on laparoscopic cases this experience has not been reproduced. By several recent studies, pregnant patients may undergo laparoscopic surgery safely during any trimester without any appreciated increased risk to the mother or fetus. It has been suggested that delaying surgical intervention in patients with symptomatic gallstone disease during pregnancy may lead to further complications of gallstone disease such as acute cholecystitis and gallstone pancreatitis which can lead to higher spontaneous abortion rates and preterm labor.

During pregnancy gestational age limit is 26 to 28 weeks as has been suggested for successful completion of laparoscopic surgery. This has been refuted by several studies in which laparoscopic cholecystectomy and appendectomy have been successfully performed late in the third trimester.

Although with good fetal and maternal outcomes laparoscopy can be performed safely in pregnancy, the long-term effects to the children have not been well studied. One recent study evaluated eleven children from one to eight years and found no growth or developmental delay.

IV. Treatment

In the pregnant patient there are many advantages of laparoscopy including: decreased fetal depression due to lessened postoperative narcotic requirements, lower risk of wound complications, diminished postoperative maternal hypoventilation, shorter hospital stays, and decreased risks of thromboembolic events due to early mobilization. Laparoscopy reduces the risk of uterine irritability by decreasing the need for uterine manipulation because of improved visualization. Decreased uterine irritability results in lower rates of spontaneous abortion and preterm delivery.

Patient Positioning

In a supine position when the pregnant patient is placed, the gravid uterus places pressure on the inferior vena cava resulting in decreased venous return to the heart. This decrease in venous return results in maternal hypotension, reduction in cardiac output by 10% to 30% and decreased placental perfusion during surgery, placing the patient in a left lateral recumbent position will shift the uterus off the vena cava improving venous return and cardiac output.

Initial Port Placement

Regarding abdominal access there has been much debate toward either a Hassan technique or Verres needle in the pregnant patient with preferences. The concern for use of the Verres needle technique has largely been based on concerns for higher likelihood of injury as fundal height increases to the uterus or other intra-abdominal organs. Because the intra-abdominal domain is altered by the increasing fundal height adaptation of the initial access site from the umbilicus to subcostal regions as the uterus enlarges in the second and third trimester has been recommended. If the site of initial abdominal access is adjusted according to fundal height and the abdominal wall is elevated during insertion, both the Hassan technique and Verres needle can be safely and effectively utilized.

It has also been recommended that placement of trocars is adjusted according to fundal height and that they are inserted under direct visualization. Ultrasound guided trocar placement has been described in the literature as an additional method to visualize trocar placement.

Insufflation Pressure

The potential effects of CO_2 insufflations on the pregnant patient and her fetus have led to apprehension over its use. The pulmonary effects of pneumoperitoneum in the pregnant patient and the potential risk for acidosis to the fetus have caused concern and have led some investigators to develop alternative approaches of gasless laparoscopy, but these have not been widely adopted.

By the growing fetus the pregnant patient's diaphragm is upwardly displaced, which results in decreased residual lung volume and functional residual capacity making her more susceptible to arterial oxygen desaturation. With existing restrictive pulmonary physiology, upward displacement of the diaphragm by pneumoperitoneum is more worrisome in a pregnant patient. Recommended by many intra-abdominal insufflation pressures be maintained at less than 12 mmHg to avoid worsening pulmonary physiology in this population. Others have argued that insufflation less than 12 mmHg may not provide adequate visualization of the intra-abdominal cavity. During laparoscopy Pressures of 15 mmHg have been implemented in pregnant patients without increasing adverse outcomes to the patient or her fetus.

Because CO_2 exchange occurs with intra-peritoneal insufflations, there has been concern for effects to the fetus, specifically the effects of acidosis. Some animal studies have confirmed fetal acidosis with associated tachycardia, hypertension and hypercapnia during CO_2 pneumoperitoneum. Other studies on animal have demonstrated no fetal acidosis. Regardless, no long-term adverse effects have been identified. Of more interest, there is no evidence to support long term detrimental effects resulting from CO_2 pneumoperitoneum in humans.

Intra-operative CO2 Monitoring

Fetal acidosis and associated fetal instability in CO2 pneumoperitoneum have been documented in animal studies, though no long-term effects from these changes have been identified. In the human fetus, fetal acidosis with insufflation has not been documented, but concerns over potential detrimental effects of acidosis have led to the recommendation of maternal CO2 monitoring. Initially, there was debate over maternal blood gas monitoring of arterial carbon dioxide ($PaCO_2$) versus end-tidal carbon dioxide ($ETCO_2$) monitoring, but the less invasive capnography has been demonstrated to adequately reflect maternal acid/base status in humans. Several large studies have documented the safety and efficacy of $EtCO_2$ measurements in pregnant women making routine blood gas monitoring unnecessary.

Venous Thromboembolic (VTE) Prophylaxis

With a 0.1-0.2% incidence of deep venous thrombosis Pregnancy is a hypercoagulable state. By increasing venous stasis, CO2 pneumoperitoneum may increase the risk of deep venous thrombosis. Even insufflation of 12 mmHg causes a statistically significant decrease in blood flow that cannot be completely reversed with intermittent pneumatic compression devices or intermittent electric calf stimulators. There is unfortunately a paucity of research on prophylaxis for deep venous thrombosis in the pregnant patient. Because of the increased risk of thrombosis, prophylaxis with pneumatic compression devices both intra-operatively and post-operatively and early postoperative ambulation are recommended as they are in the non-pregnant patient. For prophylaxis in pregnant patients undergoing laparoscopy there is no data regarding use of unfractionated or low molecular weight heparin, though its use has been suggested in patients undergoing extended major surgery. In patients that require anticoagulation during pregnancy, heparin has proven safe with monitoring and is the agent of choice

Gallbladder Disease

With some recommending initial non-operative management, Management of symptomatic cholelithiasis in pregnancy has been controversial. In 92% of patients those in favor of early surgical management are supported by the recurrence of symptomatic gallstones during pregnancy managed non-operatively who present in the first trimester, 64% presenting in the second, and 44% in the third. More important than recurrence, this delay in surgical management results in significant morbidity including; increased hospitalizations, spontaneous abortions, preterm labor, and preterm delivery compared to those undergoing cholecystectomy. In addition, non-operative management boasts a reported 57% symptom recurrence during pregnancy in patients with biliary colic and a 23% complication rate of acute cholecystitis and gallstone pancreatitis. Gallstone pancreatitis results in fetal loss in 10% to 60% of pregnant patients. The significant morbidity and mortality associated with gallbladder disease in the gravid patient argue in favor of surgical management. When compared to open cholecystectomy, the laparoscopic approach has equivalent outcomes and the well established added benefits of laparosopy. With decreased risk of spontaneous abortion improved outcomes and preterm labor have been reported in laparoscopic cholecystectomy when compared to laparotomy.

Choledocholithiasis

During pregnancy, Complications associated with choledocholithiasis are relatively uncommon. However, these complications can result in significant morbidity and mortality making appropriate management of these patients important. Unfortunately, there have been no trials comparing common bile duct exploration at the time of laparoscopic cholecystectomy to endoscopic retrograde cholangiopancreatography followed by cholecystectomy. Good outcomes have been described with intra-operative common bile duct exploration, but few cases have been reported. Multiple studies have demonstrated safe and effective management of common bile duct stones with endoscopic retrograde cholangiopancreatography with sphincterotomy and subsequent laparoscopic cholecystectomy.

Laparoscopic Appendectomy

In the gravid patient Laparoscopic appendectomy has become increasingly utilized since its introduction and is considered by many to be the standard of care. By the anatomic changes and leukocytosis associated with pregnancy, Diagnosis of appendicitis is thought to be complicated. A recent article, however, has shown that the majority (> 83%) of gravid patients with acute appendicitis present with classic right lower quadrant pain. Negative appendectomy rates in the gravid patient have been reported as high as 22% to 55%. These high negative appendectomy rates may be due to the surgeon's propensity to prevent perforation and avoid unnecessary morbidity and mortality.

When the diagnosis of appendicitis by ultrasound is equivocal, promptly proceeding to diagnostic laparoscopy or CT scan may allow for early identification and intervention in appendicitis decreasing the rate of perforation. 25% of all pregnant women who have acute appendicts will develop perforated appendicitis. A 66 % perforation events has been reported when surgery is delayed by more than 24 hours compared to 0% events when surgical management is conducted prior to 24 hours of presentation. Of note, compared to the first and second trimesters, perforation of the appendix occurs twice as often in the third trimester (69%).

Solid Organ Resection

Surgeons began exploring laparoscopy in the management of other surgical diseases that arise in pregnancy after successful laparoscopic management of appendicitis and gallbladder disease in pregnancy. During pregnancy Laparoscopic adrenalectomy has proven effective in the management of primary hyperaldosteronism, Cushing's syndrome, and pheochromocytoma. Laparoscopic splenectomy has also become an increasingly accepted surgical approach in pregnancy. Gravid patients with antiphospholipid syndrome, hereditary spherocytosis, and autoimmune thrombocytopenia purpura have undergone laparoscopic splenectomy with excellent outcomes for mother and fetus. More recently, two cases of laparoscopic nephrectomy have been reported in the first and second trimester without any associated complications and both infants were born healthy at term.

Adnexal Masses

2% is The incidence of adnexal masses during pregnancy. During the first trimester most of these adnexal masses discovered are functional cysts that resolve spontaneously by the second trimester. Expectant management has been recommended for ≤ 6cm adnexal masses in the pregnant patient based on an 82% to 94% rate of spontaneous resolution. Persistent masses are most commonly functional cysts or mature cystic teratomas with the incidence of malignancy reported at 2% to 6%. Historically, the concern over malignant potential and risks associated with emergency surgery has led to elective removal of masses that persist at 16 weeks and are > 6 cm in diameter. However, when ultrasound findings are not concerning for malignancy, recent literature supports the safety of close observation in these patients, tumor markers are normal (CA125, LDH) and the patient is asymptomatic. In the event that surgery is indicated, various case reports support the use of laparoscopy in the management of adnexal masses in every trimester. Perhaps more informative, a retrospective review of 88 pregnant women demonstrated equivalent maternal and fetal outcomes in adnexal masses managed laparoscopically and by laparotomy.

Adnexal Torsion

Adnexal masses of 10% to 15% undergo torsion. In the gravid patient, Laparoscopy is the preferred method of both diagnosis and treatment with adnexal torsion. Multiple case reports have confirmed safety and efficacy of laparoscopy for adnexal torsion in pregnant patients. If diagnosed before tissue necrosis, adnexal torsion may be managed by simple laparoscopic adnexal detorsion. However, with late diagnosis of torsion adnexal infarction may ensue, which left untreated can result in peritonitis, spontaneous abortion, preterm delivery and death. The gangrenous adnexa should be completely resected and progesterone therapy initiated after removal of the corpus luteum if less than 12 weeks gestation. Laparotomy may be necessary as dictated by the patient's clinical severity and intra-operative findings.

V. Peri-operative Care

Fetal Heart Monitoring

While, to detect fetal distress during laparoscopy, intra-operative fetal heart rate monitoring was once thought to be the most accurate method, no intra-operative fetal heart rate abnormalities have been reported in the literature. This has led some to recommend preoperative and postoperative monitoring of the fetal heart rate with no increased fetal morbidity having been reported.

Obstetrical Consultation

Maternal and fetal monitoring should be part of any pregnant patient's care and continue throughout their hospitalization, but the timing of a formal obstetric consultation will change based on availability and the acuteness of the patient's condition. Delay in the treatment of an acute abdominal process to obtain such a consultation should be avoided as treatment delay may increase the risk of morbidity and mortality to the mother and fetus.

Tocolytics

With tocolytic therapy threatened preterm labor can be successfully managed. The specific agent and indications for the use of tocolytics should be individualized. An obstetric consultation may be necessary as controversy exists over which of several agents is the preferred. No literature supports the use of prophylactic tocolytics.

Diagnosis and Workup

A. Imaging Techniques

Ultrasound

Guideline 1: Ultrasonographic imaging during pregnancy is safe and useful in identifying the etiology of acute abdominal pain in the pregnant patient (Level II, Grade A).

Risk of Ionizing Radiation

Guideline 2: Expeditious and accurate diagnosis should take precedence over concerns for ionizing radiation. In the first 25 weeks of pregnancy Radiation dosage should be limited to 5-10 rads (Level III, Grade B).

Computed Tomography

Guideline 3: Contemporary multi-detector CT protocols deliver a radiation dose to the fetus below detrimental levels and may be considered as an appropriate test during pregnancy depending on the clinical situation (Level III, Grade B).

Magnetic Resonance Imaging

Guideline 4: at any stage of pregnancy, MR Imaging can be performed without intravenous Gadolinium (Level III, Grade B).

Nuclear Medicine

Guideline 5: Nuclear Medicine administration of radionucleotides can generally be accomplished at fetal radiation levels of exposure that are well below any known detrimental levels (Level III, Grade C).

Cholangiography

Guideline 6: Intra-operative and endoscopic cholangiography exposes the mother and fetus to minimal radiation and may be used selectively during pregnancy. The lower abdomen should be shielded when performing cholangiography during pregnancy to decrease the radiation exposure to the fetus (Level III, Grade B).

B. Surgical techniques

Guideline 7: when used selectively, Diagnostic laparoscopy is safe and effective in the workup and treatment of acute abdominal processes in pregnancy (Level II, Grade B).

Patient Selection

Pre-operative Decision Making

Guideline 8: In pregnant and non-pregnant patients, Laparoscopic treatment of acute abdominal processes has the same indications (Level II, Grade B).

Laparoscopy and Trimester of Pregnancy

Guideline 9: Laparoscopy can be safely performed during any trimester of pregnancy (Level II, Grade B).

Treatment

Patient Positioning

Guideline 10: To minimize compression of the vena cava and the aorta gravid patients should be placed in the left lateral recumbent position (Level II, Grade B).

Initial Port Placement

Guideline 11: if the location is adjusted according to fundal height, Initial access can be safely accomplished with an open or Hassan, Verres needle or optical trocar, previous incisions and experience of the surgeon (Level III, Grade B).

Insufflation Pressure

Guideline 12: CO2 insufflation of 10-15 mmHg can be safely used for laparoscopy in the pregnant patient. Intra-abdominal pressure should be sufficient to allow for adequate visualization (Level III, Grade C).

Intra-operative CO2 monitoring

Guideline 13: In the pregnant patient, Intra-operative CO2 monitoring by capnography should be used during laparoscopy (Level III, Grade C).

Venous Thromboembolic (VTE) Prophylaxis

Guideline 14: Intra-operative and post-operative pneumatic compression devices and early post-operative ambulation are recommended prophylaxis for deep venous thrombosis in the gravid patient (Level III, Grade C).

Gallbladder Disease

Guideline 15: Laparoscopic cholecystectomy is the treatment of choice in the pregnant patient with gallbladder disease regardless of trimester (Level II, Grade B).

Choledocholithiasis

Guideline 16: Choledocholithiasiss during pregnancy may be managed with preoperative endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy followed by laparoscopic cholecystectomy, intra-operative laparoscopic transcystic or choledochotomy common bile duct exploration, or post-operative ERCP depending on local resources and clinical scenario (Level III, Grade C).

Laparoscopic Appendectomy

Guideline 17: Laparoscopic appendectomy may be performed safely in any patients with suspicion of appendicitis (Level II, Grade B).

Solid Organ Resection

Guideline 18: Laparoscopic adrenalectomy, nephrectomy, splenectomy and mesenteric cyst excision are safe procedures in pregnant patients when indicated and standard precautions are taken (Level III, Grade C).

Adnexal Mass

Guideline 19: Laparoscopy is safe and effective treatment in gravid patients with symptomatic cystic masses. Observation is acceptable for all other cystic lesions provided ultrasound is non-worrisome for malignancy and tumor markers are normal. Initial observation is warranted for most cystic lesions < 6 cm in size (Level III, Grade C).

Adnexal Torsion

Guideline 20: Laparoscopy is recommended for both diagnosis and treatment of adnexal torsion unless clinical severity warrants laparotomy (Level III, Grade C).

Peri-operative care

Fetal Heart Monitoring

Guideline 21: In the setting of urgent abdominal surgery Fetal heart monitoring should occur pre and postoperatively during pregnancy (Level III, Grade B).

Obstetrical Consultation

Guideline 22: Obstetric consultation can be obtained pre and/or postoperatively based on the acuteness of the patient's disease and availability (Level III, Grade B).

Tocolytics

Guideline 23: Tocolytics should not be used prophylactically, but should be considered peri-operatively when signs of preterm labor are present in coordination with obstetric consultation (Level I, Grade A).